CEVE 411 / 511
ATMOSPHERIC PROCESSES
FALL 2014

Meeting Times and Location:
M/W/F 9:00-9:50 a.m., Mech Lab 251

Instructor:
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Office Hours:
Thursdays 1:30–3:30 pm. Office visits are also welcomed at other times by appointment.

Course Description:
This course will explore the chemical and physical processes that govern the formation, transformation, and transport of gases and particles in the atmosphere. The primary phenomena of focus will be atmospheric transport; global climate change; stratospheric ozone depletion; tropospheric ozone formation and related oxidant and reactive nitrogen chemistry; acid deposition; particulate matter; and mercury and other air toxics. While our primary focus will be the atmospheric chemistry and physics processes that influence these phenomena, we will also consider the broader context of environmental policy, control technologies, and impacts on human health and the environment.

Course Objectives and Expected Learning Outcomes:
Students completing this course will be able to:

1. Solve equations and simplified models representing physical and chemical processes in the atmosphere
2. Describe the photochemical processes that destroy stratospheric ozone and form tropospheric ozone under a range of conditions
3. Diagram the processes influencing Earth's radiative balance
4. Compare and contrast the challenges posed by air pollution, ozone depletion and climate change, and key policies that have been enacted to address them
5. Critically review published literature regarding the current state of scientific understanding for climate change and air pollution

The course addresses the following ABET student outcomes for the BSCE degree:

(a) an ability to apply knowledge of mathematics, science, and engineering;
(b) an ability to design a system … to meet desired needs within realistic constraints such as economic, environmental, social, political, … and sustainability;
(d) an ability to function on multidisciplinary teams;
(e) an ability to identify, formulate, and solve engineering problems;
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
(j) a knowledge of contemporary issues

Prerequisites:
Students are expected to have a background in the fundamentals of chemistry, physics, and calculus, equivalent to CHEM 121/122; MATH 101/102; and PHYS 101. Please contact the instructor if you have questions regarding your preparation.

Textbook and Readings:
Daniel Jacob. *Introduction to Atmospheric Chemistry*. Princeton University Press, 1999. (available as pdf at http://acmg.seas.harvard.edu/publications/jacobbook/index.html)
[Recommended for students continuing in atmospheric science: John Seinfeld and Spyros Pandis. *Atmospheric Chemistry and Physics, Second Edition.* 2006.]
Additional readings will be made available on the OwlSpace website for the course.

Honor Code Policy:
All students are expected to adhere to the Rice Honor Code. The following specific expectations apply to this class:

- Exams will be given under the honor system and must be entirely a student's own work, using only resources that are explicitly authorized for that exam.
- Problem sets may be discussed with other students but must be written individually by each student in their own words.
- Plagiarism is unacceptable. Specifically, for all written work (including the paper as well as paragraph or short essay questions on the problem sets) students must both cite references used and express all ideas in their own words. Any direct quotation must be explicitly noted in quotation marks.

Disability Statement:
If you have a documented disability that will impact your work in this class, please contact me to discuss your needs. Additionally, you will need to contact the Disability Support Services Office in the Allen Center.

Grading:
Students will be evaluated by their performance on the following:

Assignments (~6)	20%
Midterm Exam I	15%
Midterm Exam II	15%
Group Project	20%
Final Exam	30%

Assignments are due in class on the due date unless otherwise specified. Late assignments will incur a penalty of 25 points and will not be accepted after solutions are distributed. The **group project** will involve teams in developing an integrated strategy for a State to achieve air quality and greenhouse gas mitigation objectives. **Attendance and participation** can change the final grade by +/- 3 points, determined by considering your self-assessment of the adjustment you deserve (-3 points = no attendance; 0 = attendance but no participation; +3 = active participation). Graduate students (CEVE 511) will be assigned a more challenging group project assignment, and will also be assigned an additional problem on some problem sets.

SCHEDULE (*subject to change*)

DATE	THEME	TOPIC	READING
8/25	**Introduction to the Atmosphere**	Importance of the Atmosphere	
8/27		Structure of the Atmosphere (measures of composition; layers; pressure; barometric law)	Jacob Ch. 1, Ch. 2
8/29		Simple models of the Atmosphere	Jacob Ch. 3
9/1		**LABOR DAY (no class)**	
9/3	**Atmospheric Transport**	Horizontal transport (Earth-Sun geometry; Coriolis force)	Jacob Ch. 4.1
9/5		Horizontal transport (friction; Hadley and general circulation)	Jacob Ch. 4.1-4.2
9/8		Vertical Transport (buoyancy; stability; inversions; cloud formation)	Jacob Ch. 4.3
9/10		Vertical Transport (cont.)	
9/12		Turbulence and Diffusion	Jacob Ch. 4.4
9/15		Tropical cyclones	Reading on Owlspace
9/17	**Climate Change**	Intro to Climate Change and its impacts	IPCC reading
9/19		Biogeochemical cycles of oxygen and carbon	Jacob Ch. 6
9/22		Radiative Balance of the Atmosphere	Jacob Ch. 7.1-7.2
9/24		Greenhouse Effect	Jacob Ch. 7.3
9/26		Radiative forcing and climate response	Jacob Ch. 7.4-7.5
9/29		Natural climate variability; Aerosols and climate	Readings on Owlspace
10/1		Mitigation, adaptation, and geo-engineering	Readings on Owlspace
10/3	**MIDTERM 1**		
10/6	**Stratospheric Ozone**	Chemical kinetics and photolysis	Jacob Ch. 9
10/8		Intro to Stratospheric Ozone; Chapman Mechanism ozone formation	Jacob Ch. 10.1; Readings on Owlspace
10/10		Catalytic cycles of ozone destruction (NO_x and HO_x)	Jacob Ch. 10.2
10/13		**MIDTERM RECESS (no class)**	
10/15		Halogen cycles of ozone destruction; interaction between cycles	

DATE	THEME	TOPIC	READING
10/17		Ozone depletion at poles and beyond; Heterogeneous stratospheric chemistry	Jacob Ch. 10.3
10/20	**Tropospheric Chemistry (Ozone)**	Policies for stratospheric ozone; Intro to Tropospheric Ozone; Hydroxyl radical	Jacob Ch. 11.1
10/22		Basic NO_x cycle; Carbon monoxide and O_3 formation	Jacob Ch. 11.2
10/24		Methane: Sources, sinks, and oxidation	Jacob Ch. 11.2
10/27		VOC oxidation; NO_x- and VOC-limited ozone formation	Jacob Ch. 11.3, Ch. 12
10/29		Daytime & nighttime NO_x and NO_y chemistry (including PAN & HONO); ozone production efficiency	Readings on Owlspace
10/31		Policies and technologies to control ground-level ozone; Houston ozone	
11/3	**MIDTERM 2**		
11/5	**Acid Deposition**	Acid deposition and its impacts; Natural acidity of rain	Jacob Ch. 13
11/7		Sulfur Chemistry	S&P Ch. 2.2; 7.3.3; 7.5; 22.1
11/10		Other gases influencing acid rain; Control policies and technologies	S&P Ch. 7.3.4-7.3.6
11/12	**Particulate Matter**	Importance of particulate matter; Properties of particles	TBD
11/14		Visibility	S&P Ch. 15
11/17		Sulfate, Nitrate, and Ammonium Particles	TBD
11/19		Carbonaceous Particles	TBD
11/21		Policies and technologies to control particulate matter	
11/24	**Air Toxics**	Mercury, Benzene, and Other air toxics	Readings on Owlspace
11/26		No class	
11/28		**THANKSGIVING RECESS**	
12/1	**Group Presentations**	(May need an extended class period, TBD)	
12/3		No class (or guest lecture TBD)	
12/5	**Synthesis and Review**	Comparing the ozone depletion, air pollution, and climate change challenges; Exam review	
TBD	**FINAL EXAM**	**(take-home)**	